(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 360 360 A2**

(12) **EUROPEAN PATENT APPLICATION**

(21) Application number: 89202391.2

(51) Int. Cl.5: B04C 5/081

(22) Date of filing: 21.09.89

(30) Priority: 22.09.88 GB 8822348

(43) Date of publication of application: 28.03.90 Bulletin 90/13

(84) Designated Contracting States: BE DE ES FR GB IT NL

(71) Applicant: SHELL INTERNATIONALE RESEARCH MAATSCHAPPIJ B.V.
Carel van Bylandtlaan 30
NL-2596 HR Den Haag(NL)

(72) Inventor: van den Akker, Hendrikus Egidius Antonia
Badhuisweg 3
NL-1031 CM Amsterdam(NL)
Inventor: de Kort, Cornelius Josephus Maria
Badhuisweg 3
NL-1031 CM Amsterdam(NL)

(74) Representative: Aalbers, Onno et al
P.O. Box 302
NL-2501 CH The Hague(NL)

(54) Swirl tube separator.

(57) Swirl tube separator comprising a cylindrical housing (1) having an inlet part (3) at its upper end and a solids outlet opening (5) at its lower end part. The inlet part (3) is provided with swirl imparting means (19). A swirl zone (20) extends in the housing (1) between the swirl imparting means (19) and the solids outlet opening (5). An open-ended fluid outlet conduit (11) is arranged concentrically in the housing (1) and comprises a primary section (13) extending into the inlet part (3) of the housing (1), a downwardly tapering frustoconical section (15) joined to the lower end of the primary section (13), and a secondary section (17) having a diameter equal to the smallest diameter of the frustoconical section (15) and joined to the lower end of the frustoconical section (15). The ratio of the distance between the lower ends of the fluid outlet conduit (11) and the swirl zone (20) to the inner diameter of the housing (1) is between 1.0 and 3.0.

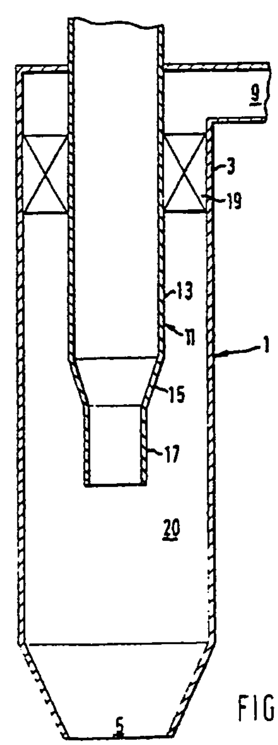

FIG.1

EP 0 360 360 A2

SWIRL TUBE SEPARATOR

The present invention relates to a swirl tube separator for the separation of solids from a mixture of fluid and solids.

The separation of solids from a mixture of fluid and solid particles using a swirl tube separator is based on different centrifugal forces acting on the fluid and the solids of the swirling mixture.

USA patent specification No. 2 890 764 discloses a swirl tube separator for separating solids from a mixture of fluid and solids, the separator comprising:

- a housing having a cylindrical mid section;
- an inlet opening for the mixture arranged near a first end of the housing;
- a solids outlet opening arranged near a second end of the housing;
- a fluid outlet conduit being arranged concentrically within the housing, said outlet conduit comprising a small diameter section, a large diameter section and a frustoconical section for interconnecting the small diameter section and the large diameter section, the small diameter section having a free end which is in direct fluid communication with the interior of the housing and the large diameter section extending through said first end of the housing; and
- a swirl zone which extends, when the separator is being used, through the interior of the housing from near the inlet opening to a location near the solids outlet opening.

The lower end of the fluid outlet conduit coincides with the lower end of the swirl zone.

As can be seen in Figures 10 and 14 of the prior art document the ratio of the distance from said free end of the small diameter section of the fluid outlet conduit to the location to which the swirl zone extends and the inner diameter of the cylindrical mid section of the housing is much less than 1.

Applicants have now found that the separation efficiency of a swirl tube separator can be improved by selecting a larger ratio between said dimensions.

Accordingly, it is an object of the present invention to provide a swirl tube separator having a higher separation efficiency than the known separator.

To this end the swirl tube separator according to the invention is characterized in that the specific distance from said free end of the small diameter section of the fluid outlet conduit to said location near the solids outlet opening to which the swirl zone extends is between 1.0 and 3.0.

Here the specific distance is referred to as the ratio of the above-mentioned distance to the inner diameter of the cylindrical mid section of the housing.

Hereinafter in the specification and in the claims the expressions "specific distance", "specific length" and "specific inner diameter" are used to refer to the ratio of said distance, length and inner diameter to the inner diameter of the cylindrical mid section of the housing.

The invention will now be described by way of example in more detail with reference to the accompanying drawings, wherein:

Figure 1, shows schematically a cross-section of the swirl tube separator according to the invention; and

Figure 2, shows schematically a cross-section of an alternative swirl tube separator according to the invention.

Reference is made to Figure 1. The swirl tube separator comprises a housing 1 having an inlet part 3 at its upper end and a solids outlet opening 5 at its lower end part. The inlet part 3 is in communication with an inlet opening 9.

An open-ended fluid outlet conduit 11 extends concentrically into the housing 1. The lower end of the fluid outlet conduit 11 is arranged between the inlet part 3 and the solids outlet opening 5. The fluid outlet conduit 11 comprises a large diameter section in the form of a primary section 13, a downwardly tapering frustoconical section 15 joined to the lower end of the primary section 13, and a small diameter section in the form of a secondary section 17 joined to the lower end of the frustoconical section 15. The largest inner diameter of the frustoconical section 15 is equal to the inner diameter of the primary section 13 and the smallest inner diameter of the frustoconical section 15 is equal to the inner diameter of the secondary section 17.

Swirl imparting means in the form of swirl vanes 19 are arranged in the inlet part 3 and between the inner wall of the housing 1 and the outer wall of the primary section 13 of the fluid outlet conduit 11.

A swirl zone 20 extends in the housing 1 between the swirl imparting means in the form of swirl vanes 19 and the solids outlet opening 5.

During normal operation a mixture of gas and solid particles is introduced into the inlet part 3 through inlet opening 9. The mixture flows downwardly between the inner wall of the housing 1 and the outer wall of the primary section 13 of the fluid outlet conduit 11, and passes the swirl vanes 19, which swirl vanes 19 impart a swirl to the mixture. The swirling mixture forms a vortex in the swirl zone 20.

The swirling solid particles in the mixture are flung towards the inner wall of the housing 1 by the centrifugal forces acting on them. At the inner wall of the housing 1 the solid particles flow downwardly by gravitational forces. The solid particles are discharged from the swirl zone 20 through the solids outlet opening 5.

The gas in the vortex is withdrawn from the swirl zone 20 through the fluid outlet conduit 11.

The alternative swirl tube separator shown in Figure 2 is additionally provided with a vortex stabilizer 21 arranged at or near the solids outlet opening 5. The vortex stabilizer 21 comprises a vortex stabilizer plate 23 arranged perpendicular to the central longitudinal axis of the housing 1, and a vortex finder rod 25 arranged parallel to the central longitudinal axis of the housing 1 and extending in the direction of the fluid outlet conduit 11.

Normal operation of the alternative swirl tube separator is similar to normal operation of the swirl tube separator with reference to Figure 1. The function of the vortex stabilizer is to stabilize the vortex in the housing 1 and to delimit the lower end of the vortex.

The inlet part 3 of the housing 1 may alternatively be provided with swirl imparting means in the form of a tangential inlet (not shown).

Normal operation of a swirl tube separator provided with a tangential inlet is similar to normal operation of the swirl tube separator provided with swirl vanes 19.

The swirl tube separator according to the invention is similarly operated when a mixture of liquid and solid particles is introduced into the inlet part 3.

It has been found that the discharge of solid particles through the fluid outlet conduit can be further reduced by choosing the dimensions of the swirl tube separator according to each of the following specifications: the specific length of the secondary section 17 of the fluid outlet conduit 11 to be between 0.25 and 1.0, the specific length of the frustoconical section 15 of the fluid outlet conduit 11 to be between 0.20 and 0.30, the specific inner diameter of the secondary section 17 of the fluid outlet conduit 11 to be between 0.20 and 0.40, the specific inner diameter of the primary section 13 of the fluid outlet conduit 11 to be between 0.55 and 0.75, the specific length of the primary section 13 of the fluid outlet conduit 11 to be between 1.0 and 1.4, and the specific length of the inlet part 3 to be between 0.50 and 0.70.

The following experiments 1-3 have been carried out to illustrate the swirl tube separator according to the invention.

The expression "swirl number" is used to refer to the ratio of the tangential component of the mixture velocity to the axial component of the mixture velocity.

Experiment 1

The swirl tube separator used in experiment 1 had the following characteristics: specific distance between lower ends of the fluid outlet conduit and the swirl zone = 2.18, specific length of the secondary section of the fluid outlet conduit = 0.57, specific length of the frustoconical section of the fluid outlet conduit = 0.26, specific length of the primary section of the fluid outlet conduit = 1.21, specific length of the inlet part = 0.60, specific inner diameter of the secondary section of the fluid outlet conduit = 0.38, specific inner diameter of the primary section of the fluid outlet conduit = 0.65.

A mixture of gas and solid particles was supplied to the inlet part of the cylindrical housing. The gas had a density of 1.23 kg/m^3 and the pressure difference between the gas at the inlet part and in the fluid outlet conduit was 1930 Pa. The swirl number of the mixture in the swirl zone near the swirl imparting means was 1.73. The mixture contained 0.092 kg/m^3 solid particles having a mean diameter of 14 μm. As a result it was found that 99.63% of the solid particles was discharged through the solids outlet opening and 0.37% through the fluid outlet conduit.

Experiment 2

The swirl tube separator used in experiment 2 had the following characteristics: specific distance between lower ends of the fluid outlet conduit and the swirl zone = 2.43, specific length of the secondary section of the fluid outlet conduit = 0.31, specific length of the frustoconical section of the fluid outlet conduit = 0.26, specific length of the primary section of the fluid outlet conduit = 1.21, specific length of the inlet part = 0.60, specific inner diameter of the secondary section of the fluid outlet conduit = 0.38, specific inner diameter of the primary section of the fluid outlet conduit = 0.65. A mixture of gas and solid particles was supplied to the inlet part of the cylindrical housing. The gas had a density of 1.23 kg/m^3 and the pressure difference between the gas at the inlet part and in the fluid outlet conduit was 2000 Pa. The swirl number of the mixture in the swirl zone near the swirl imparting means was 1.73. The mixture contained 0.092 kg/m^3 solid particles having a mean diameter of 14 μm. As a result it was found that 99.47% of the solid particles was discharged through the solids outlet opening and 0.53% through the fluid outlet conduit.

Experiment 3

The swirl tube separator used in experiment 3 had the following characteristics: specific distance between lower ends of the fluid outlet conduit and the swirl zone = 1.96, specific length of the secondary section of the fluid outlet conduit = 0.78, specific length of the frustoconical section of the fluid outlet conduit = 0.26, specific length of the primary section of the fluid outlet conduit = 1.21, specific length of the inlet part = 0.60, specific inner diameter of the secondary section of the fluid outlet conduit = 0.38, specific inner diameter of the primary section of the fluid outlet conduit = 0.65.

A mixture of gas and solid particles was supplied to the inlet part of the cylindrical housing. The gas had a density of 1.23 kg/m³ and the pressure difference between the gas at the inlet part and in the fluid outlet conduit was 1980 Pa. The swirl number of the mixture in the swirl zone near the swirl imparting means was 1.73. The mixture contained 0.093 kg/m³ solid particles having a mean diameter of 14 µm. As a result it was found that 99.57% of the solid particles was discharged through the solids outlet opening and 0.43% through the fluid outlet conduit.

The following experiments 4-6 have been carried out as comparison.

Experiment 4

The swirl tube separator used in experiment 4 had the following characteristics: specific distance between lower ends of the fluid outlet conduit and the swirl zone = 1.53, specific length of the secondary section of the fluid outlet conduit = 1.21, specific length of the frustoconical section of the fluid outlet conduit = 0.26, specific length of the primary section of the fluid outlet conduit = 1.21, specific length of the inlet part = 0.60, specific inner diameter of the secondary section of the fluid outlet conduit = 0.38, specific inner diameter of the primary section of the fluid outlet conduit = 0.65.

A mixture of gas and solid particles was supplied to the inlet part of the cylindrical housing. The gas had a density of 1.23 kg/m³ and the pressure difference between the gas at the inlet part and in the fluid outlet conduit was 1920 Pa. The swirl number of the mixture in the swirl zone near the swirl imparting means was 1.73. The mixture contained 0.095 kg/m³ solid particles having a mean diameter of 14 µm. As a result it was found that 99.49% of the solid particles was discharged through the solids outlet opening and 0.51% through the fluid outlet conduit.

Experiment 5

The swirl tube separator used in experiment 5 had the following characteristics: specific distance between lower ends of the fluid outlet conduit and the swirl zone = 1.86, specific length of the secondary section of the fluid outlet conduit = 0.56, specific length of the frustoconical section of the fluid outlet conduit = 0.56, specific length of the primary section of the fluid outlet conduit = 1.21, specific length of the inlet part = 0.60, specific inner diameter of the secondary section of the fluid outlet conduit = 0.38, specific inner diameter of the primary section of the fluid outlet conduit = 0.65.

A mixture of gas and solid particles was supplied to the inlet part of the cylindrical housing. The gas had a density of 1.23 kg/m³ and the pressure difference between the gas at the inlet part and in the fluid outlet conduit was 1830 Pa. The swirl number of the mixture in the swirl zone near the swirl imparting means was 1.73. The mixture contained 0.093 kg/m³ solid particles having a mean diameter of 14 µm. As a result it was found that 99.53% of the solid particles was discharged through the solids outlet opening and 0.47% through the fluid outlet conduit.

Experiment 6

The swirl tube separator used in experiment 6 had the following characteristics: specific distance between lower ends of the fluid outlet conduit and the swirl zone = 1.74, specific length of the secondary section of the fluid outlet conduit = 1.07, specific length of the frustoconical section of the fluid outlet conduit = 0.26, specific length of the primary section of the fluid outlet conduit = 1.21, specific length of the inlet part = 0.60 specific inner diameter of the secondary section of the fluid outlet conduit = 0.46, specific inner diameter of the primary section of the fluid outlet conduit = 0.65.

A mixture of gas and solid particles was supplied to the inlet part of the cylindrical housing. The gas had a density of 1.23 kg/m³ and the pressure difference between the gas at the inlet part and at the fluid outlet conduit was 1260 Pa. The swirl number of the mixture in the swirl zone near the swirl imparting means was 1.73. The mixture contained 0.093 kg/m³ solid particles having a mean diameter of 14 µm. As a result it was found that 98.92% of the solid particles was discharged through the solids outlet opening and 1.08% through the fluid outlet conduit.

Claims

1. A swirl tube separator for separating solids from a mixture of fluid and solids, the separator comprising:
- a housing having a cylindrical mid section;
- an inlet opening for the mixture arranged near a first end of the housing;
- a solids outlet opening arranged near a second end of the housing;
- a fluid outlet conduit being arranged concentrically within the housing, said outlet conduit comprising a small diameter section, a large diameter section and a frustoconical section for interconnecting the small diameter section and the large diameter section, the small diameter section having a free end which is in direct fluid communication with the interior of the housing and the large diameter section extending through said first end of the housing; and
- a swirl zone which extends, when the separator is being used, through the interior of the housing from near the inlet opening to a location near the solids outlet opening; characterized in that the specific distance from said free end of the small diameter section of the fluid outlet conduit to said location near the solids outlet opening to which the swirl zone extends is between 1.0 and 3.0.

2. Swirl tube separator of claim 1 wherein said location near the solids outlet opening to which the swirl zone extends is defined by the location at which a vortex stabilizer is mounted within the housing.

3. Swirl tube separator of claim 1 wherein the solids outlet opening is formed by a tapered frustoconical end section of the housing and said location to which said swirl zone extends is formed by the downstream end of said frustoconical end section of the housing.

4. Swirl tube separator of claim 1, wherein swirl imparting means are arranged in an inlet part of the housing, which inlet part is arranged near the first end of said housing.

5. Swirl tube separator according to any one of claims 1-4, wherein the specific length of the small diameter section of the fluid outlet conduit is between 0.25 and 1.0.

6. Swirl tube separator according to any one of the claims 1-5, wherein the specific length of the frustoconical section of the fluid outlet conduit is between 0.20 and 0.30.

7. Swirl tube separator according to any one of the claims 1-6, wherein the specific inner diameter of the small diameter section of the fluid outlet conduit is between 0.20 and 0.40.

8. Swirl tube separator according to any one of the claims 1-7, wherein the specific inner diameter of the large diameter section of the fluid outlet conduit is between 0.55 and 0.75.

9. Swirl tube separator according to any one of the claims 1-8, wherein the specific length of the large diameter section of the fluid outlet conduit is between 1.0 and 1.4.

10. Swirl tube separator according to any one of the claims 4-9, wherein the specific length of the inlet part of the housing is between 0.50 and 0.70.

11. Swirl tube separator according to any one of the claims 1-10, wherein the largest inner diameter of the frustoconical section is equal to or smaller than the inner diameter of the large diameter section of the fluid outlet conduit.

12. Swirl tube separator substantially as described in the specification with reference to Figures 1 and 2.

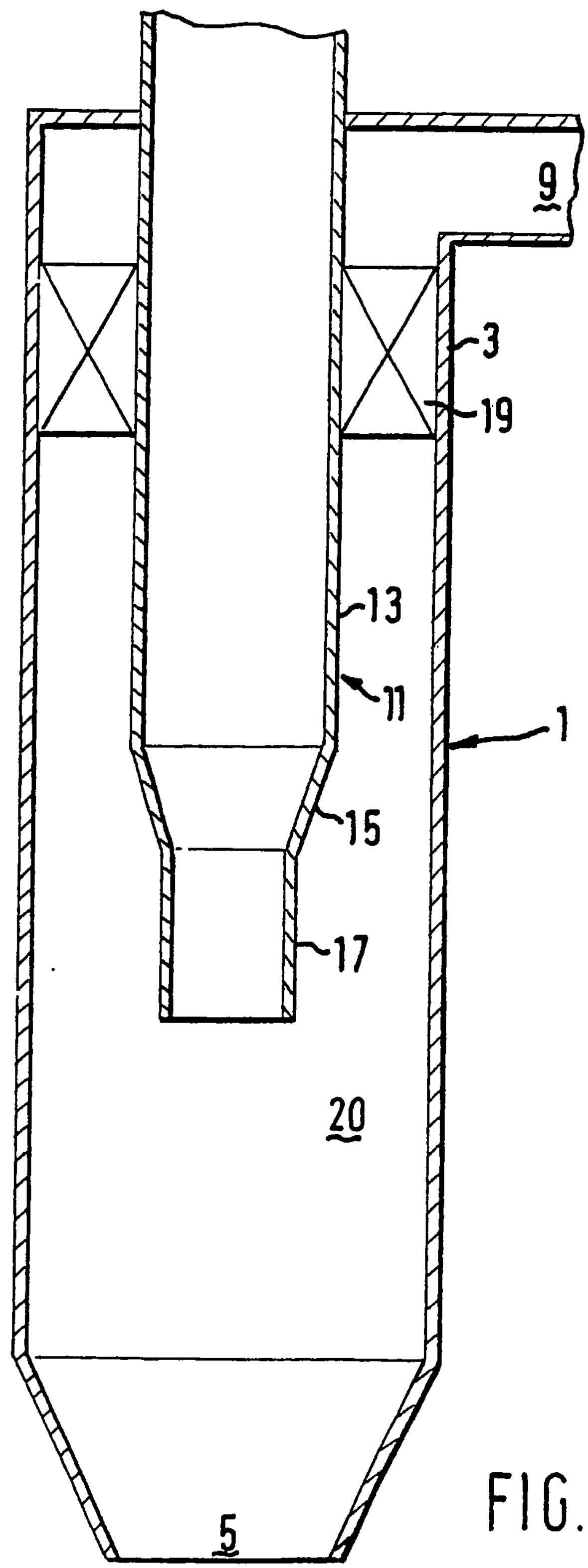

FIG.1

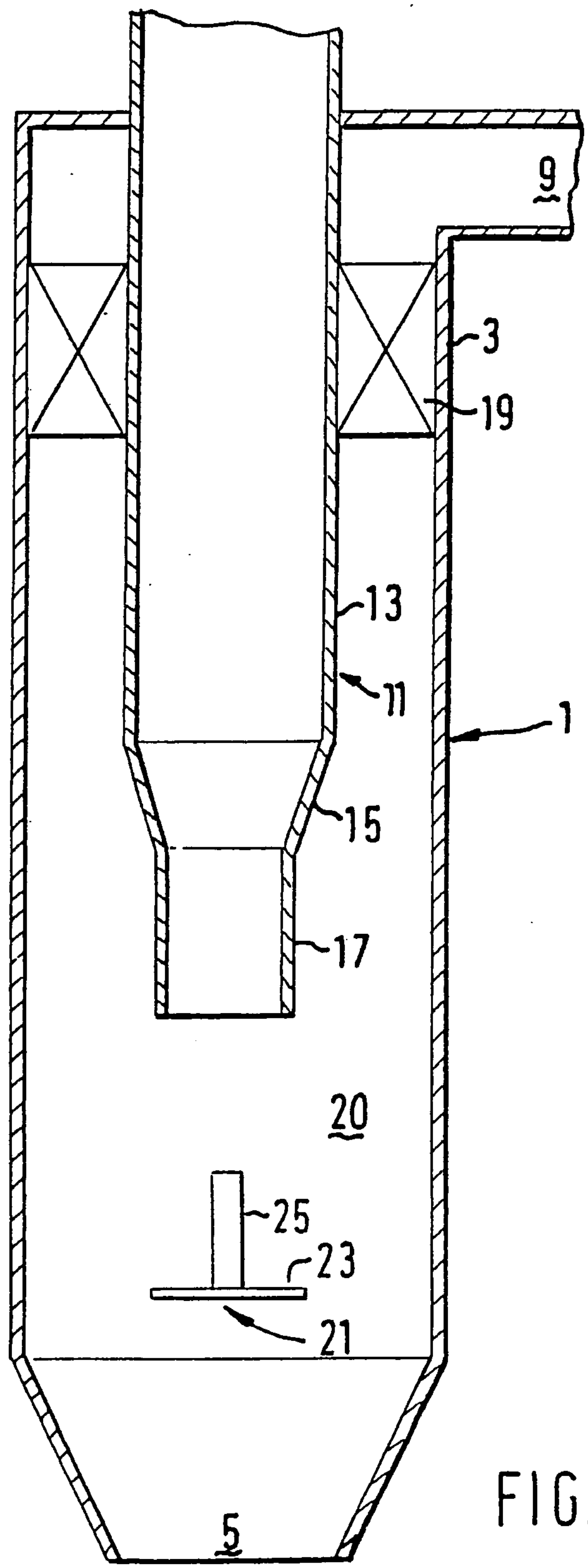

FIG. 2

(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 360 360 A3**

(12) # EUROPEAN PATENT APPLICATION

(21) Application number: 89202391.2

(51) Int. Cl.5: **B04C 5/081**

(22) Date of filing: 21.09.89

(30) Priority: 22.09.88 GB 8822348

(43) Date of publication of application:
28.03.90 Bulletin 90/13

(84) Designated Contracting States:
BE DE ES FR GB IT NL

(88) Date of deferred publication of the search report:
30.01.91 Bulletin 91/05

(71) Applicant: SHELL INTERNATIONALE RESEARCH MAATSCHAPPIJ B.V.
Carel van Bylandtlaan 30
NL-2596 HR Den Haag(NL)

(72) Inventor: van den Akker, Hendrikus Egidius Antonia
Badhuisweg 3
NL-1031 CM Amsterdam(NL)
Inventor: de Kort, Cornelius Josephus Maria
Badhuisweg 3
NL-1031 CM Amsterdam(NL)

(74) Representative: Aalbers, Onno et al
P.O. Box 302
NL-2501 CH The Hague(NL)

(54) **Swirl tube separator.**

(57) Swirl tube separator comprising a cylindrical housing (1) having an inlet part (3) at its upper end and a solids outlet opening (5) at its lower end part. The inlet part (3) is provided with swirl imparting means (19). A swirl zone (20) extends in the housing (1) between the swirl imparting means (19) and the solids outlet opening (5). An open-ended fluid outlet conduit (11) is arranged concentrically in the housing (1) and comprises a primary section (13) extending into the inlet part (3) of the housing (1), a downwardly tapering frustoconical section (15) joined to the lower end of the primary section (13), and a secondary section (17) having a diameter equal to the smallest diameter of the frustoconical section (15) and joined to the lower end of the frustoconical section (15). The ratio of the distance between the lower ends of the fluid outlet conduit (11) and the swirl zone (20) to the inner diameter of the housing (1) is between 1.0 and 3.0.

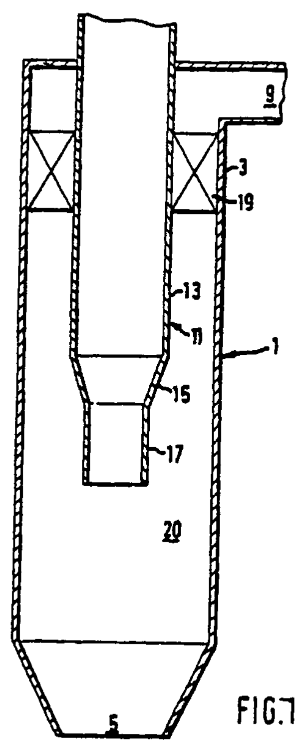

FIG.1

EP 0 360 360 A3

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 89 20 2391

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X	US-A-3 273 320 (L.J. DELAUME et al.) * Column 4, line 59 - column 5, line 18; figure 1 * ---	1,3-8, 10-12	B 04 C 5/081
Y	GB-A-2 132 511 (SHELL) * Page 3, lines 53-56; figure 2 * ---	1,2,4,11, 12	
Y	WO-A-8 303 986 (BAUER BROS) * Page 7, line 24 - page 10, line 23; figure 1 * ---	1,2,4,11, 12	
Y	US-A-3 636 682 (J.B. RUSH) * Column 3, line 1- column 4, line 14; figures 1,2 * ---	1,3-9,11, 12	
A	US-A-2 667 944 (J. CRITES) * Column 1, line 40 - column 4, line 8; figures 1-3 * ---	1,3,4, 10-12	
A	AUFBEREITUNGS-TECHNIK, vol. 29, no. 7, July 1988, pages 395-402, Wiesbaden, DE; M. GEBICA: "A contribution to pressure loss and dedusting efficiency of cyclones" * Page 396, figure 1; page 399, table 4 * ---	1,3,4, 10-12	
A,D	US-A-2 890 764 (G.D. ARNOLD) -----		TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			B 04 C

The present search report has been drawn up for all claims

Place of search	Date of completion of search	Examiner
The Hague	27 November 90	LAVAL J.C.A

CATEGORY OF CITED DOCUMENTS

X: particularly relevant if taken alone
Y: particularly relevant if combined with another document of the same catagory
A: technological background
O: non-written disclosure
P: intermediate document
T: theory or principle underlying the invention

E: earlier patent document, but published on, or after the filing date
D: document cited in the application
L: document cited for other reasons

&: member of the same patent family, corresponding document